FUTURE IRRIGATION EXPANSION

Study elements were included which called for ground water simulations to show the effects of potential new irrigation over the ESPA. One aspect of the concurrent IWRB planning study for the ESPA was to identify lands which potentially could support new irrigation development. Areas considered by the IWRB study to have the greatest potential for future irrigation development were:

Trust water area:

(a)   Expansion within larger blocks of land adjacent to presently irrigated areas, most likely using a combination of ground and surface water sources. An example is northern Power County just east of the Wapi Lava Flow.

(b)   Non-irrigated lands in western Clark County between Medicine Lodge and Birch Creeks. This land would be irrigated primarily with surface water from these and other tributary valleys with some ground water supplementation.

(c)   In-fills within presently irrigated lands.

Non-trust water area:

(a)   In-fills within presently irrigated lands using both ground and surface water sources.

Many of the acres identified as having some potential for new irrigation also have physical limitations, such as adverse climate, soil conditions, or topography that would limit irrigation expansion. Other areas are restricted by the economics of water delivery such as extreme distance from a surface source or prohibitive pumping costs associated with deep wells. The potentially irrigable land under federal administrative jurisdictions such as the Bureau of Land Management, Forest Service, INEEL, and National Park Service, and the land under tribal jurisdiction were not considered for new irrigation as were areas under state designation as a Ground Water Management Area or Critical Ground Water Area.

The conclusion is that the most practicable development scenarios available for irrigation expansion are limited to areas immediately adjacent to already irrigated tracts, primarily in-fills within the larger irrigated areas, and small "islands" of presently non-irrigated or under-irrigated lands within the area shown to be presently irrigated. These include center pivot corners, isolated small tracts, and other pieces that have not been irrigated. The acreage available for irrigation expansion in these areas is assumed to be small. In addition, lands within the trust water area of the Swan Falls Agreement present special problems of development with expansions limited to 10,000 acres per year, up to a maximum allowable development of 50,000 acres.

Based on this information it was concluded in the IWRB planning study (IWRB, 1997, in press) that the potential for irrigation of new land on the ESPA is limited to the degree that such irrigation will not be significant in the foreseeable future. Therefore no model simulations were made relative to irrigation expansion.

ESPA TRIBUTARY BASIN PLANS

The technical committee included a study element to identify and develop plans of study for areas tributary to the ESPA where ground water development may significantly affect surface water users. The committee felt that tributary issues concerning ground and surface water rights were similar to those on the ESPA itself. The committee recommended plans of study be prepared, along with associated costs and issues for each area, but considered any completed studies beyond the scope of this effort.

REVIEW OF BASIN CHARACTERISTICS

Twenty basins tributary to the ESPA were identified (Figure 28) and an intensive review of the characteristics of each basin was made. Only the tributary area lying outside the boundary of the ESPA ground water model or the HFA ground water model were included in the analysis. It was assumed that areas lying within the ESPA model area where ground water development has taken place are already accounted for in that model even though some areas may technically be considered as tributaries.

Basin information was obtained from previous studies, the IDWR water rights data base, land use data, well driller's logs, and existing water-level data. Selected physical and hydrologic data were compiled for each basin. Water rights and land use data were used to assess the level of ground water development in the basins. Plots showing annual and cumulative totals of the number of ground water rights and their diversion rates were made. Agricultural lands in each of the tributary basins were mapped. These maps were developed from 1986 Landsat classification data. Water-level hydrographs from observation wells that are representative of the basin's ground water trends were prepared. A bibliography of publications which describe the ground water hydrology of each basin was made. This information was assembled and prepared as a separate document entitled "Eastern Snake Plain Aquifer Tributary Valley Information." The document is in loose leaf form allowing updates to be made periodically as new information becomes available.

STUDY PRIORITIZATION

Due to the large number of tributary basins and limited resources available, a priority system for further study was developed based on need. The information from the basin reviews was used as input to a ranking system. The ranking system is based on the level of historic and current ground water activity in a basin. Water rights were the primary indicator used to develop each priority. When available, long-term ground water trends assisted in the ranking decisions. From these data,

each of the basins were ranked according to their relative impact on the plain. Three levels of priority were identified: high, medium, and low. The criteria used to determine each of the levels are presented below.

> *High Priority* -- Total authorized ground water diversion rate exceeds 500 cfs, and a high growth rate based on historic trends (water rights, land use, and water levels).

> *Medium Priority* -- Total authorized ground water diversion rate between 100 cfs and 500 cfs, and a medium growth rate based on historic trends (water rights, land use, and water levels).

> *Low Priority* -- Total authorized ground water diversion rate less than 100 cfs, and a low growth rate based on historic trends (water rights, land use, and water levels).

The ranking for each tributary basin along with key hydrologic and water right support data are presented in Table 8. Rankings and associated information were used as a basis for developing the appropriate study methodology and can also provide a priority list for initiating tributary basin studies.

PROPOSED MODELING APPROACH

To assess the transient effects of ground water use in the tributary basins, a single-stress stream-aquifer modeling approach is proposed for each basin. Each model would simulate the effects of a single stress on each stream-aquifer system. That is, the models would simulate the effects of ground water withdrawal (or other stress, if desired) on tributary stream flow and underflow leaving the basin. The results from each model would be input into the ESPA ground water model and then the Snake River surface water accounting model (see "Impacts of ESPA Ground Water Irrigation on Water District 1 Surface Water Users" section) to determine the effect on users in Water District 1.

MODFLOW, a finite-difference ground-water flow model developed by McDonald and Harbaugh (1988), will be used to simulate stream-aquifer conditions in each of the twenty tributary basins. Utilizing the principle of superposition described by Reilly, et. al. (1987), the model will simulate changes in tributary stream flow and underflow leaving each basin due to ground water withdrawal. Recharge to the aquifer from stream losses will be the only recharge component in each simulation. Other sources of recharge such as infiltration from local precipitation and unconsumed irrigation water will not be included in the simulations. Simulations will be conducted with flat water tables and no aquifer recharge or discharge. Under these conditions there is no gradient between the stream and aquifer and, therefore, no water movement between them.

51

Advantages of Proposed Method:

- Offers a simplified and direct technique for simulating the time-varied effects of ground water withdrawal on stream flow and underflow leaving each basin.

- Model results will provide estimates of the impacts of tributary basin ground water development on Upper Snake River surface water users.

- Offers a standardized approach for evaluating impacts of ground-water withdrawal on stream flow and underflow for each tributary basin, regardless of its size and level of development. Modeling results from each basin can be easily and equally compared when utilizing the same method.

- Although the methodology used for each basin is the same, the level of effort for data collecting and compiling, and model construction can vary. Estimated number of man-months to study Birch Creek, a low priority basin, is three; whereas, Portneuf River, a high priority basin, is six.

- Less time intensive and costly than a conventional multi-stress model. Preliminary estimates of time and cost savings are approximately 50 percent.

- If interest and resources justify using a conventional multi-stress modeling approach for any basin, the results from the single-stress method will be a necessary and useful step in conducting a more in-depth study of a basin. There would be no duplication of effort.

PROPOSED PROJECT METHODOLOGY

Each tributary basin project will be composed of six steps. These include: data collection, data compilation, model construction, model validation, model utilization, and final report. Study elements of each step are outlined below. The proposed study plan as applied to each tributary basin could be revised based on the particularities of each basin or as additional information is developed.

Data Collection:

- Review previous studies to understand relationship between stream-aquifer system.

- Review well driller's reports for principal lithologies, depth of aquifer penetration, and specific capacity data.

- If appropriate, conduct aquifer tests.

- Measure depth to water in selected wells if water-level data are unavailable.

- Conduct field survey of tributary stream to determine average streambed widths and depths for hydraulically connected stream-aquifer reaches.

- If appropriate, perform stream flow reach gain and loss measurements.

- Determine the percentages of ground water irrigated crops from field surveys, Soil Conservation Service, and other sources.

Data Compilation:

- Create digital base map of tributary basin (include township and range lines, major streams, highways, towns, and boundaries of ESPA model and HFA model).

- Determine physical boundaries of aquifer from geologic maps and previous studies.

- Determine areal distribution of principal lithologies that comprise aquifer from well driller's reports and previous studies.

- Digitize boundaries of aquifer and principal lithologies.

- Estimate apparent thickness of principal lithologies of aquifer using maximum depths of penetration from well driller's reports.

- Compute values of hydraulic conductivity and specific yield for principal lithologies from specific capacity and aquifer test data.

- Compute values of transmissivity for each principal lithology from mean values of hydraulic conductivity and estimated thickness.

- Compile irrigated acreage data from best available sources (USBR, Landsat imagery, etc.) for basin. Overlay adjudication water right data to identify acreage irrigated with ground water.

- Compute average monthly ground water depletion rates from estimates of ground water irrigated acreage, percentages of each ground water irrigated crop, and the average monthly consumptive use for each crop.

- Create profile of tributary stream stage and ground water surface using topographic maps and depth to water data.

- Determine locations of hydraulically connected stream-aquifer reaches from profile.

- Determine lengths of hydraulically connected stream-aquifer reaches.

- Estimate streambed thickness using 20 percent of the estimated stream width. Top and bottom of the streambed are based on estimated stream depth and estimated streambed thickness.

- If stream flow reach gain and loss data are available, compute values of streambed hydraulic conductivity. If not, assume a value one tenth of the mean hydraulic conductivity computed for the aquifer.

- Compute values of streambed hydraulic conductance for each hydraulically connected stream-aquifer reach using computed or estimated values of streambed hydraulic conductivity.

- Estimate mean monthly stream flow for hydraulically connected stream-aquifer reaches using data from continuous stream gages, reach lengths, and reach gain and loss measurements.

Model Construction:

- Define model as a transient simulation with the number of annual cycles corresponding to the median age of ground water rights for the basin. Each annual cycle will consist of seven stress periods representing the six months of irrigation from April to September and one six-month period of non-irrigation from October to March. The total number of stress periods will be equal to the number of annual cycles times seven.

- Define model grid with axes oriented sub-parallel to principal direction of ground water flow.

- Define model as a single layer with isotropic and confined conditions. (Anticipated drawdown will be small to relative aquifer thickness, so confined conditions should adequately simulate the unconfined conditions that prevail in the aquifer).

- Define grid cells corresponding to aquifer boundaries. Grid cells corresponding to impermeable boundaries of aquifer will be assigned no flow. Grid cells corresponding to the ESPA and/or HFA model boundaries will be assigned general head using values for hydraulic conductance based on those models.

54

- Define aquifer properties for each grid cell using mean values of transmissivity and specific yield for the principal aquifer lithologies.

- Set initial head for all grid cells equal to zero.

- Define average monthly ground water depletion rates for corresponding grid cells for each stress period. Hold values constant for same monthly stress periods throughout entire simulation. Set stress periods that correspond to six-month non-irrigation period equal to zero.

- Define stream-aquifer parameters for corresponding grid cells using computed values for streambed hydraulic conductance, stream flow, and top and bottom of the streambed. Stream stage will be set equal to zero. Hold values constant for all parameters throughout entire simulation.

Model Validation:

Most model simulations that include all components of stress (recharge and discharge) to an aquifer are commonly tested or validated by means of a calibration process. This process generally entails comparing simulated water levels with measured water levels and adjusting the hydraulic properties of the aquifer and stream bed until an acceptable match occurs. Since the single-stress modeling approach does not simulate the complete hydrologic system, alternate methods must be used to validate the results of these models. They include:

- Evaluate overall water balance from model simulation to assure that each component is within reasonable limits.

- Perform sensitivity analyses of stream-aquifer parameters by adjusting these values to within reasonable hydrologic limits and evaluating the range in simulated stream depletion.

- When possible, compare simulated stream losses and gains with measured values and adjust stream-aquifer parameters accordingly.

- Evaluate simulated values for underflow depletion at general head boundary of model to assure that they are within a reasonable percentage of estimated total basin underflow.

Model Utilization:

Modeling results for a tributary basin will be input into the ESPA ground water model and the Snake River surface water accounting model in order to distribute the estimated impact on surface water users throughout Upper Snake River basin (Water District 1). The following procedure will be used:

- Input values for underflow depletion and/or surface recharge from the tributary basin model into the ESPA and/or HFA ground water models at the corresponding boundary grid cells.

- Run ESPA model to obtain simulated impacts on reach gains to the Snake River. Compare results with base study to determine depletion in reach gains.

- Input reach gain depletion and/or stream depletion into the Water District 1 accounting model to estimate changes in availability of natural surface flow and resulting changes in storage water accrual and use for surface water users (see procedure described in "Impacts of ESPA Ground Water Irrigation on Water District 1 Surface Water Users" section).

FINAL REPORT

A final report will be prepared for each tributary basin study. The reports will include descriptions of the general hydrogeology, data collection and compilation effort, model construction and validation steps, and final model utilization. Report figures will include maps of the study area, general geology, well locations and stream gaging sites, ground water irrigated lands, model grid and boundary conditions. Graphs showing ground water development history, mean monthly irrigation requirements, measured stream losses and gains, simulated stream and underflow depletion will also be included. Upon completion of all tributary basin studies, a summary report will be prepared outlining results from each basin study.

BASIN PROJECT PLANS AND COSTS

Individual tributary basin project plans and issues and procedures pertinent to each basin project are presented in Appendix F. Estimates of time and cost to perform each tributary project are listed in Table 9. It is estimated that it would take approximately 85 man months to complete all twenty tributary projects at a 1997 cost of $510,000, including $36,000 and 6 man months for Geographical Information Systems (GIS) costs. These cost are further broken down into the high, medium, and low priority categories described above. The five high priority basin projects could be completed at a cost of $144,000 plus GIS costs (which remain constant regardless of the number of basins completed) for a total of $180,000. The high priority tributary projects could be completed with 30 man months of effort.
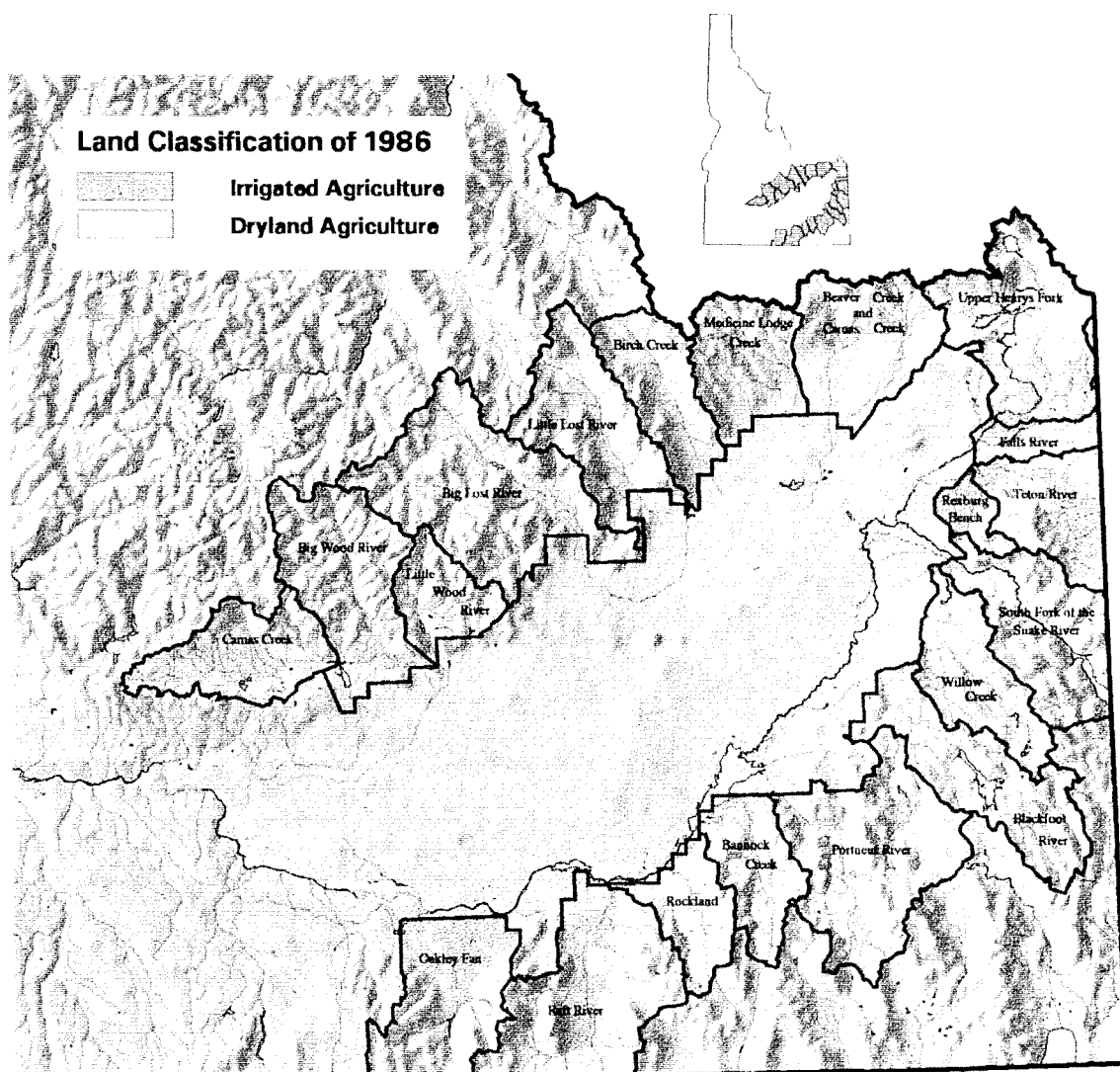
56

Figure 28. Upper Snake River Tributary Basins

Land Classification of 1986
Irrigated Agriculture
Dryland Agriculture

Table 8. Hydrologic Summary of Tributary Basins

Priority	Tributary Basin	Drainage Area (mi^2)	Authorized Ground Water Diversion Rate (cfs)	Total Irrigated Land: 1986 Est. (ac)	Precipitation (1000 ac-ft/yr)	Basin Outflow (1000 ac-ft/yr)	
						Surface Water	Ground Water
Low	Upper Henrys Fork	1,060	10	33,500	1,487 - 1,978	1,088	0
Low	Falls River/Conant Creek	520	13	41,200	971	579	0
Medium	Teton River	890	355	143,200	1,058	597	0
High	Rexburg Bench	165	925	58,500	141 - 174	10	0 - 19
Low	South Fork of Snake River	5,750	24	25,300	10,216	5,022	0
Low	Willow Creek	650	25	5,200	534	100	0 - 29
Low	Blackfoot River	930	18	9,600	987	267	0 - 25
High	Portneuf River	1,290	550	90,700	1,128	202	49 - 63
Medium	Bannock Creek	410	365	45,600	393	28	22 - 30
Low	Rockland	430	58	19,800	295	17	51
High	Raft River	1,510	1,825	104,800	1,248	0	84
High	Oakley Fan	1,630	2,220	171,200	1,347	210	215
Medium	Camas/Beaver Creeks	830	195	14,700	872	37	267
Medium	Medicine Lodge Creek	830	285	9,700	872	41	20 - 30
Low	Birch Creek	600	5	1,400	749	0	57 - 78
Medium	Little Lost River	840	120	11,500	1,147	52	100
High	Big Lost River	1,440	510	69,800	1,206 - 1,551	74	142 - 308
Low	Little Wood River	480	36	26,800	566	124	13 - 24
Medium	Big Wood River/Silver Creek	1,180	345	27,000	1,492	330	38
Medium	Camas Prairie	680	155	110,300	638	128	20

58

Table 9.   Time and Cost Estimates of Proposed Tributary Basin Studies

Tributary Basin	Data Collection		Data Compilation		Model Construction		Model Validation		Model Utilization		Final Report		Basin Total	
	mm	$	mm	$	mm	$	mm	$	mm	$	mm	$	mm	$
Upper Henrys Fork	0.25	1,500	0.75	4,500	0.5	3,000	0.5	3,000	0.5	3,000	1.0	6,000	3.5	21,000
Falls River/Conant Creek	0.25	1,500	0.25	1,500	0.5	3,000	0.5	3,000	0.5	3,000	1.0	6,000	3.0	18,000
Teton River	1.5	9,000	1.5	9,000	1.0	6,000	0.5	3,000	0.5	3,000	1.0	6,000	6.0	36,000
Rexburg Bench	0.5	3,000	1.0	6,000	0.5	3,000	0.5	3,000	0.5	3,000	1.0	6,000	4.0	24,000
South Fork of Snake River	0.25	1,500	0.25	1,500	0.5	3,000	0.5	3,000	0.5	3,000	1.0	6,000	3.0	18,000
Willow Creek	0.25	1,500	0.25	1,500	0.5	3,000	0.5	3,000	0.5	3,000	1.0	6,000	3.0	18,000
Blackfoot River	0.25	1,500	0.25	1,500	0.5	3,000	0.5	3,000	0.5	3,000	1.0	6,000	3.0	18,000
Portneuf River	1.5	9,000	1.5	9,000	1.0	6,000	0.5	3,000	0.5	3,000	1.0	6,000	6.0	36,000
Bannock Creek	1.0	6,000	1.0	6,000	0.5	3,000	0.5	3,000	0.5	3,000	1.0	6,000	4.5	27,000
Rockland	0.5	3,000	0.5	3,000	0.5	3,000	0.5	3,000	0.5	3,000	1.0	6,000	3.5	21,000
Raft River	1.0	6,000	1.5	9,000	1.0	6,000	0.5	3,000	0.5	3,000	1.0	6,000	5.5	33,000
Oakley Fan	0.25	1,500	0.75	4,500	1.0	6,000	0.5	3,000	0.5	3,000	1.0	6,000	4.0	24,000
Camas/Beaver Creeks	0.5	3,000	1.0	6,000	0.5	3,000	0.5	3,000	0.5	3,000	1.0	6,000	4.0	24,000
Medicine Lodge Creek	1.0	6,000	1.0	6,000	0.5	3,000	0.5	3,000	0.5	3,000	1.0	6,000	4.5	27,000
Birch Creek	0.25	1,500	0.25	1,500	0.5	3,000	0.5	3,000	0.5	3,000	1.0	6,000	3.0	18,000
Little Lost River	0.25	1,500	0.75	4,500	0.5	3,000	0.5	3,000	0.5	3,000	1.0	6,000	3.5	21,000
Big Lost River	0.5	3,000	1.0	6,000	1.0	6,000	0.5	3,000	0.5	3,000	1.0	6,000	4.5	27,000
Little Wood River	0.5	3,000	0.5	3,000	0.5	3,000	0.5	3,000	0.5	3,000	1.0	6,000	3.5	21,000
Big Wood River/Silver Creek	0.25	1,500	0.75	4,500	0.5	3,000	0.5	3,000	0.5	3,000	1.0	6,000	3.5	21,000
Camas Prairie	0.25	1,500	0.75	4,500	0.5	3,000	0.5	3,000	0.5	3,000	1.0	6,000	3.5	21,000
Geographic Information System work													6.0	36,000
All Twenty Tributary Basin Studies													85.0	510,000

mm = man-month

59

ESPA MANAGED RECHARGE

In an effort to retain more surface runoff from the Snake River and its tributaries in the Upper Snake River Basin and to increase ESPA water table levels and year-round spring discharge to surface streams, several plans and demonstration projects for recharging the aquifer have been developed over the past 25 years. The technical committee included a study element to prepare a plan of study for an "artificial" recharge project. The committee viewed additional recharge as potentially beneficial by increasing water supplies available in the Upper Snake River Basin and providing a tool for a conjunctive management plan. This section explores the potential opportunities for "managed" recharge which can be defined as "the addition of water to a confined or unconfined aquifer in an effective, efficient and controlled manner for the sole purpose of achieving defined and predictable responses in the aquifer as measured by ground water elevations and/or spring discharges."

Successful managed recharge of the ESPA is dependent on four factors: 1) the identification of suitable recharge sites; 2) adequate delivery systems to convey the water to the recharge sites; 3) the availability of water of suitable quality from surface sources; and 4) institutional approvals.

RECHARGE SITES AND DELIVERY SYSTEMS

To address the issue of potential recharge sites and adequate delivery systems, the University of Idaho was contracted to investigate the feasibility of using existing canals to facilitate additional recharge beyond the incidental recharge which exists as a result of normal irrigation practices. Since 1994 many canals in Water District 1 have begun to divert water above their normal irrigation needs for aquifer recharge as a result of legislation that same year which funded purchase of water from the water bank and provided funding for a portion of the conveyance costs. The identification of new recharge sites, which would require design and construction costs, was considered beyond the scope of this study.

Detailed results of the University of Idaho study are presented in a separate report (Sullivan, et al, 1996). Recharge capacities of existing (or easily modified) systems in the Upper Snake were defined in the recharge study (Table 10). Capacities were grouped according to locations in three general areas: 1) Egin, 2) Blackfoot, and 3) Milner. These capacities take into account both suitable sites and adequate delivery systems, but do not reflect adequate supply or institutional approvals.

Table 10. Canal System Capacity for Additional Managed Recharge Diversions

| Recharge Area | cfs | | | | | | | | | | | | | kaf |
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Yr	Yr
Egin	617	474	326	310	457	697	624	406	382	391	464	655	492	356
Blackfoot	853	624	20	0	275	570	1037	351	74	44	304	437	381	276
Milner	832	882	0	0	0	516	682	547	197	124	114	482	366	265

AVAILABILITY OF SURFACE WATER FOR RECHARGE

Existing canal system capacity values (Table 10) were compared with surplus natural flow and flood release availability in Water District 1 using the IDWR 1928-1992 monthly surface water planning model base study. The IDWR base study (Robertson, et al, 1989) represents flows and reservoir contents over the 65 year period under present conditions of development and operational rules. The recharge capacities at the three areas were compared to the base study surplus flows at the same locations to identify divertable amounts. Surplus flows are defined as those which would have spilled past Milner Dam and out of Water District 1 had they not been diverted and for which no other prior right would demand the water for a consumptive use. An assessment of the quality of these surplus flows was beyond the scope of this study.

There are a number of constraints that may affect the availability of water for recharge. These include hydropower water rights, Snake River water quality concerns, federal and tribal reserved water rights in the lower Snake River, and necessary flow regimes for endangered or threatened species. An evaluation of these constraints on the availability of water for recharge was beyond the scope of this study, but should be addressed in future studies. For the purpose of this study, a worst case assumption regarding the effect of hydropower water rights was used to illustrate the magnitude of potential effects these constraints could have on the amount of water available for recharge.

From the IDWR surface water base study, the average annual flow passing the Milner gaging station on the Snake River is approximately 2.3 million acre-feet. Of this amount, it was estimated that approximately 2.0 million acre-feet is surplus flow if hydropower rights are ignored. The monthly comparison of surplus flow with recharge capability yielded an annual average of 346,000 acre-feet with the potential to be diverted for recharge (Scenario A).

There are several locations on the Snake River where hydropower constraints may limit diversions to recharge. To assess the potential and extent of hydropower constraints to restrict recharge, a review was made of all major hydropower rights on the Snake River above the King Hill gaging station. The review identified major power rights not specifically subordinated to recharge and having rates large enough to impact recharge.

61

A second comparison (Scenario B) of flow availability relative to recharge capability was made to illustrate the magnitude of the potential impact of hydropower rights. Hydropower rights at three locations which may have an effect were added as a constraint on recharge water availability as follows:

St. Anthony	800 cfs
American Falls	9,000 cfs
Lower Salmon Falls	17,250 cfs

Results of this comparison yielded only 43,000 acre-feet average annual divertable flow to recharge. This example demonstrates that administration of hydropower rights can have a significant effect on managed recharge projects.

Table 11 characterizes the average annual flow of the Snake River at Milner from the IDWR surface water model base study and the recharge study results. Scenario A assumes that all power rights would be subordinated to managed recharge diversions, and Scenario B assumes that the power rights at St. Anthony, American Falls, and Lower Salmon Falls would be met before recharge could occur.

Table 11. 1928-1992 Average Annual Discharge at Milner and
Divertable Recharge Using Existing Canal Capacities

	(acre-feet)	(cfs)
Base Study	2,312,000	3190
Surplus Flow	1,987,000	2740
Divertable Recharge - Scenario A	346,000	480
Divertable Recharge - Scenario B	3,000	60

Table 11 illustrates that canal capacities limit the ability to divert surplus flow (1,987,000 acre-feet) to less than twenty percent (Scenario A). Recognition of hydropower rights (Scenario B) further limits the ability to recharge with surplus flow to about two percent of the supply.

These scenarios are examples of possible water supplies available for managed recharge. Actual constraints posed by hydropower are beyond the scope of this study and need to be investigated further. Available surface water may include additional supplies of storage water from unallocated, purchased, or rented sources. Use of storage water would increase available water supplies if used in conjunction with surplus flow, but any new use of stored water would reduce surplus flow passing through Water District 1 as a result of creating additional storage space to capture the flow. At the present time the amount of storage water available over the long term is difficult, if not impossible, to predict in view of the multitude of competing uses for stored water. It should also be noted,

however, that the following ground water simulation studies illustrating the effects of recharge are dependent on volume and location of recharge but not on whether the source is surplus flow or storage water. Results of the ground water simulations using storage would be identical to those using surplus flows assuming volumes were of the same magnitude.

AQUIFER RESPONSE

The water available for recharge from each of the above scenarios was added to the appropriate nodes in the ground water model to assess the effect of recharge on spring outflows and ground water levels over the ESPA. Seven locations were identified (Figure 29) overlying the aquifer where recharge was added based on the University of Idaho report on recharge capability of existing canals. These locations are not specific points where recharge would occur, but represent multiple sites in the general area.

Two options were modeled for each scenario. For option 1 of each scenario, the location of the recharge water was kept as low in the Upper Snake system as possible. Available water was diverted first at Milner, then Blackfoot, and if additional water was still available, finally at the Egin location. In option 2, the location of the recharge water was kept as high in the system as possible by diverting first at Egin, then Blackfoot, and finally at Milner. This was done to assess the effect on spring flows and water table elevations relative to the general location of recharge.

Crop and land use data, computation of recharge on the irrigated and non-irrigated acres, computation of irrigation diversions, climate data and crop distribution data, tributary valley underflow estimates, and river reach gains and losses were all the same as described for the base study. The boundary configuration was identical to that used in the base study. Leakage computed by the HFA ground water model for the base study was adjusted based on computed changes in head in the ESPA model underlying the HFA for each timestep (Appendix D). The model simulation used transmissivity and storage coefficient values from the initial calibration. Head values identical to the beginning timestep of the base study were used as the initial ground water surface (see "ESPA Base Study" section).

The combined recharge source term for the managed recharge studies is the average net recharge to the ESPA at the present level of development increased only by the amount of new recharge. This was done by adding injection wells at specific nodes (Figure 29) on an average annual time schedule. These inputs, for options 1 and 2 of scenarios A and B, are summarized by node and timestep in Tables 12 through 15. Estimated head values and outflows for the recharge simulations were determined by repeatedly running the 24 timestep sequence of average annual recharge source terms.

Figure 29. Managed Recharge Sites
on the Eastern Snake Plain Aquifer

5K Model Cell Size   (Hydraulically Connected)   ━━━━━   (No Flow)
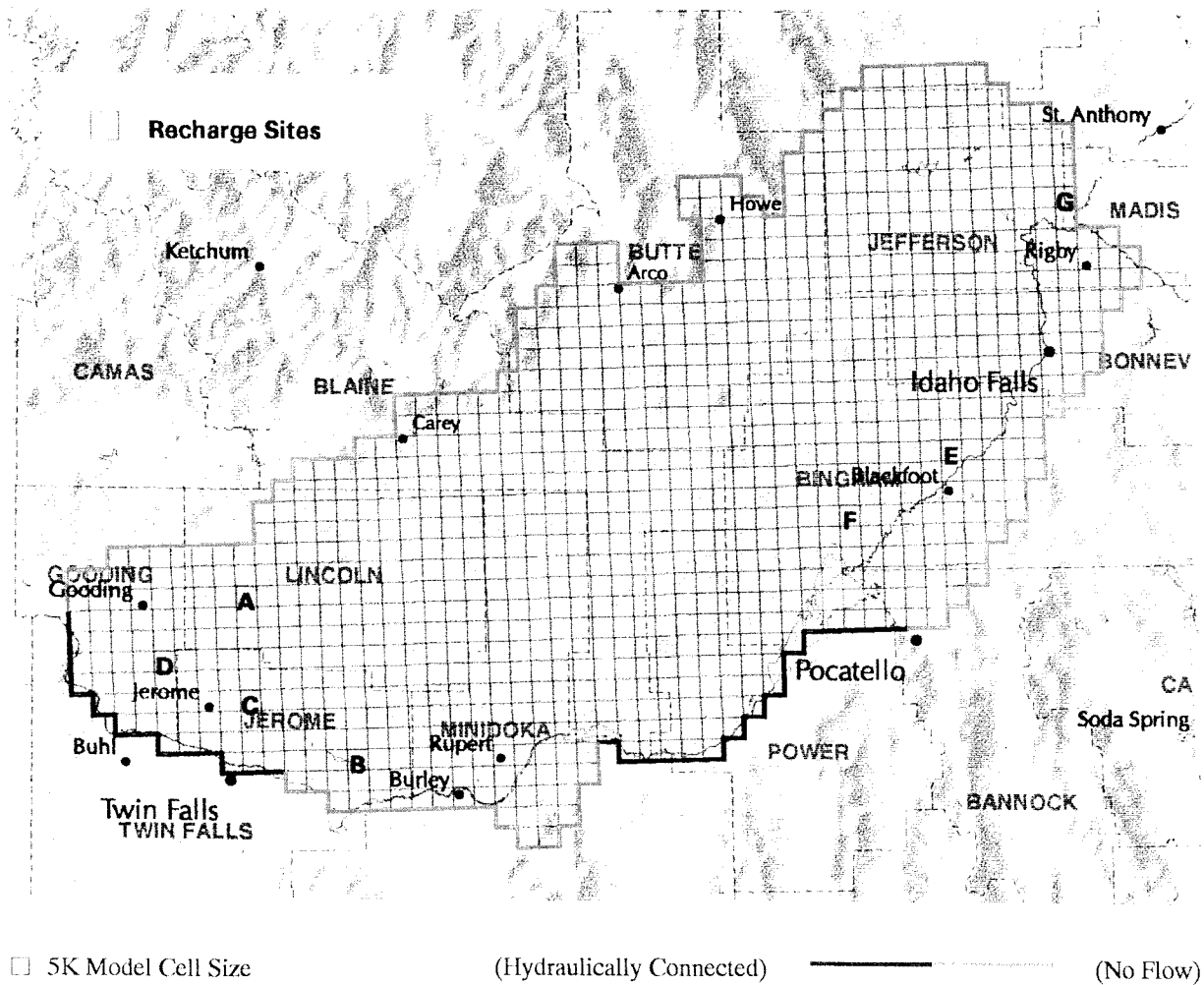
64

Table 12. Average Potential ESPA Managed Recharge Using Existing Systems and Surplus Snake River Flows

Scenario A, Option 1: Assuming Recharge Not Subject to Hydropower Constraints   -   Recharge Sequence = Milner/Blackfoot/Egin

(kaf)

Site	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
A	5.8	13.3				12.2	16.8	12.5				0.9	61.5
B	1.1	10				2.5	4.2	2.5	1.8	0.3	0.3	0.2	22.9
C	0.7	8.2				2.1	3.4	2.1	1.5	0.2	0.2	0.1	18.5
D	1.1	10				2.5	4.2	2.5	1.8	0.1	0.1	0.1	22.4
E	0.4	2.3	0.7			0.6	5.5	1.6	1.1	0.2	0.2	0.1	12.7
F	7.7	17.3			7.5	14.7	32.5	10.8	0.8		1	1.1	93.4
G	5.3	12	11.8	10.3	9.1	15.1	20.1	17.2	9.5	1.8	1.8	0.8	114.8
Total	22.1	73.1	12.5	10.3	16.6	49.7	86.7	49.2	16.5	2.6	3.6	3.3	346.2

Table 13. Average Potential ESPA Managed Recharge Using Existing Systems and Surplus Snake River Flows

Scenario A, Option 2: Assuming Recharge Not Subject to Hydropower Constraints   -   Recharge Sequence = Egin/Blackfoot/Milner

(kaf)

Site	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
A	5.2	28.2				11.5	15.7	12.1				0.2	72.9
B	1	4.7				2.3	3.9	2.4	1.7	0.2	0.2	0.1	16.5
C	0.7	3.9				2.1	3.2	2	1.4	0.1			13.4
D	1	4.7				2.3	3.9	2.4	1.7	0.2	0.2	0.1	16.5
E	0.4	1.9	0.7			0.4	5.1	1.6	1.1	0.2	0.2	0.1	11.7
F	7.3	14.4			5	12.2	30.6	10.9	0.7		1	1	83.1
G	6.6	15.4	11.8	10.3	11.6	18.7	24.3	18	9.8	1.8	1.9	1.9	132.1
Total	22.2	73.2	12.5	10.3	16.6	49.5	86.7	49.4	16.4	2.5	3.5	3.4	346.2

Table 14. Average Potential ESPA Managed Recharge Using Existing Systems and Surplus Snake River Flows

Scenario B, Option 1: Assuming Recharge Subject to Hydropower Constraints   -   Recharge Sequence = Milner/Blackfoot/Egin

(kaf)

Site	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
A		1.2				0.6	5.1	2.1					9
B		0.2				0.2	1.3	0.5	0.5				2.7
C		0.1				0.1	1	0.2	0.3				1.7
D		0.2				0.1	1.3	0.5	0.1				2.2
E		0.1	0.1			0	1.6	0.2	0.2				2.2
F		0.5				1.1	9.4	1.4	0.1				12.5
G		0.1	0.1	2.2		1.3	5.5	1.9	1.3				12.4
Total	0	2.4	0.2	2.2	0	3.4	25.2	6.8	2.5	0	0	0	42.7

Table 15. Average Potential ESPA Managed Recharge Using Existing Systems and Surplus Snake River Flows

Scenario B, Option 2: Assuming Recharge Subject to Hydropower Constraints   -   Recharge Sequence = Egin/Blackfoot/Milner

(kaf)

| Site	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
A		0.3				0.6	3.6	1.3					5.8
B		0.1				0.2	0.9	0.3	0.3				1.8
C							0.7	0.2	0.1				1
D		0.1				0.2	0.9	0.3	0.3				1.8
E		0.1					1.6	0.2	0.2				2.1
F		0.9				1.1	9.5	1.4	0.1				13
G		1	0.1	2.2		1.3	8	3	1.6				17.2
Total	0	2.5	0.1	2.2	0	3.4	25.2	6.7	2.6	0	0	0	42.7
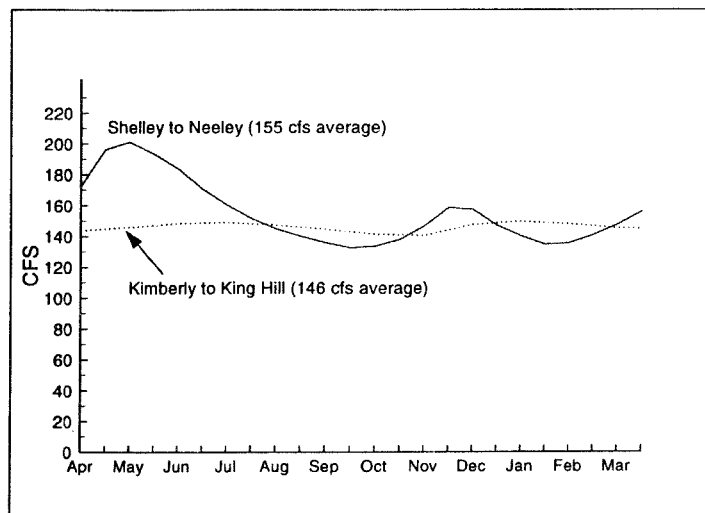
Figure 30. ESPA Managed Recharge Study Scenario A option 1, Difference in Spring Discharge from Base after 25 Years
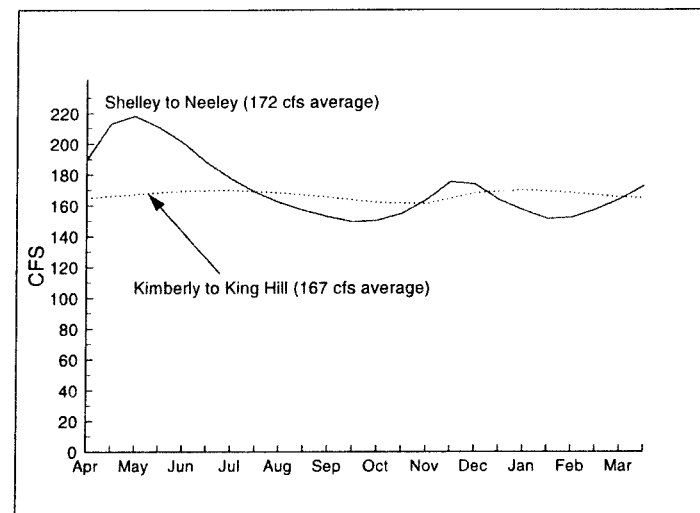
Figure 31. ESPA Managed Recharge Study Scenario A option 1, Difference in Spring Discharge from Base after 100 Years
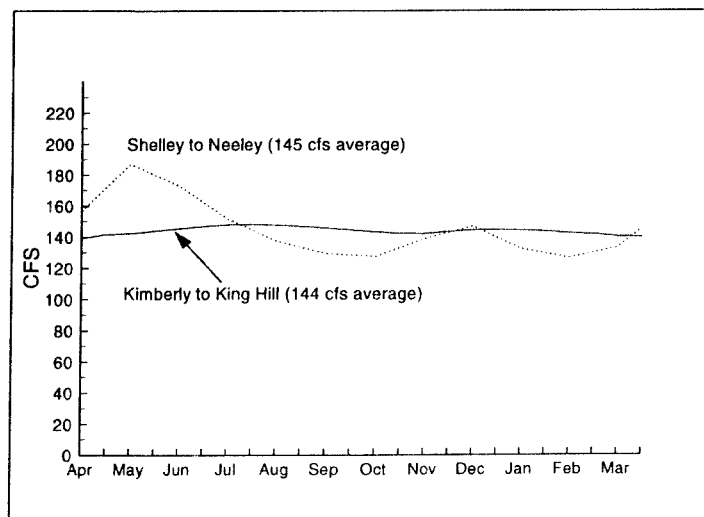
Figure 32. ESPA Managed Recharge Study Scenario A option 2, Difference in Spring Discharge from Base after 25 years
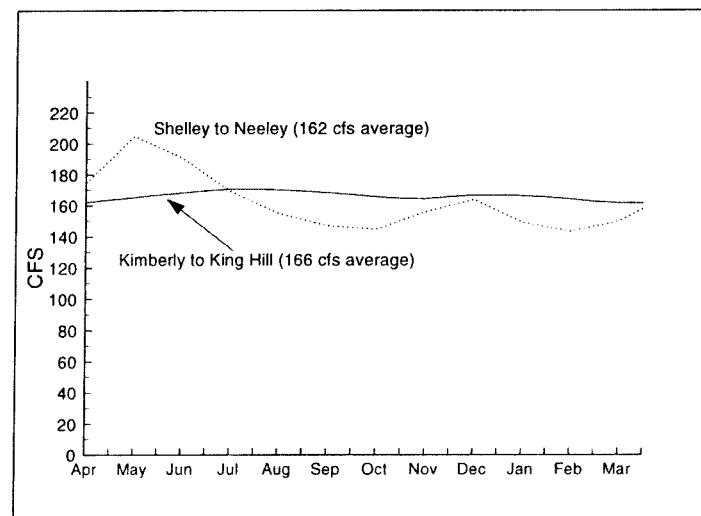
Figure 33. ESPA Managed Recharge Study Scenario A option 2, Difference in Spring Discharge from Base after 100 Years

After simulation of a one hundred year period, annual change in aquifer storage for each of the scenario A studies was approximately 11,000 acre-feet, which is indicative of equilibrium conditions. The speed at which the aquifer responds to the increase in recharge is indicated by the rate of the change in annual aquifer change in storage. The annual aquifer change in storage after year 25 for each of the scenario A studies was approximately 38,000 acre-feet.

The scenario A, option 1 study added an annual average of 346,000 acre-feet of recharge water maximized over the western ESPA (Milner/Blackfoot/Egin). After 25 years of simulation using the recharge values for scenario A, option 1, change in aquifer discharge for the Shelley to Neeley and Kimberly to King Hill reaches of the Snake River averaged 155 cfs and 146 cfs, respectively (Figure 30), and at equilibrium (100 years) averaged 172 cfs and 167 cfs, respectively (Figure 31). Leakage from the HFA to the ESPA was reduced by approximately 122 cfs and 126 cfs after 25 and 100 years, respectively.

Scenario A, option 2 is identical to Option 1 except that recharge is maximized in the eastern portion of the ESPA (Egin/Blackfoot/Milner). After 25 years of simulation, change in computed aquifer discharge for the Shelley to Neeley and Kimberly to King Hill reaches of the Snake River averaged 145 and 144 cfs, respectively (Figure 32), and after 100 years averaged 162 cfs and 166 cfs, respectively (Figure 33). Leakage from the HFA to the ESPA was reduced by approximately 138 cfs and 142 cfs after 25 and 100 years, respectively.

A comparison of options 1 and 2 shows that moving recharge to the eastern portion of the ESPA results in less leakage from the HFA. The reduced leakage translates into greater surface flow in the Henrys Fork and Rigby Fan area with an equivalent reduction in gains to the Snake River from Shelley to Neeley and Kimberly to King Hill.

Figure 34 shows the change (from base conditions) in ground water elevations over the ESPA after 25 years of simulation for scenario A, option 1. Increases in water table elevations range from less than 10 feet in the central ESPA to more than 70 feet in areas close to recharge sites. Similar increases in ground water elevations occurred for scenario A, option 2. It should be noted that although water table changes in elevation would be greater in the proximity of recharge sites, results shown here are influenced by the transmissivity of the particular node chosen for injection and may not be representative of the actual area of recharge.

Recharge for scenario B is limited to an average annual recharge of 43,000 acre-feet due to hydropower constraints. Again, scenario B, options 1 and 2 are identical except that recharge is maximized in the western portion of the ESPA (Egin/ Blackfoot/Milner) for option 1 and the eastern portion (Milner/Blackfoot/Egin) in option 2. Scenario B increases in water table elevations ranged from less than 0.5 foot in the central ESPA to less than 3 feet in areas close to recharge sites. After 25 and 100 years of simulation, change in computed aquifer discharge for the Shelley to Neeley and Kimberly to King Hill reaches of the Snake River were each less than 25 cfs for both options, as was the leakage change from the HFA to the ESPA. Therefore, it can be concluded that the magnitude of managed recharge provided by Scenario B is not significant.

Table 16 summarizes the four managed recharge studies listing changes in Snake River gains and changes in Henrys Fork gains due to change in HFA leakage.

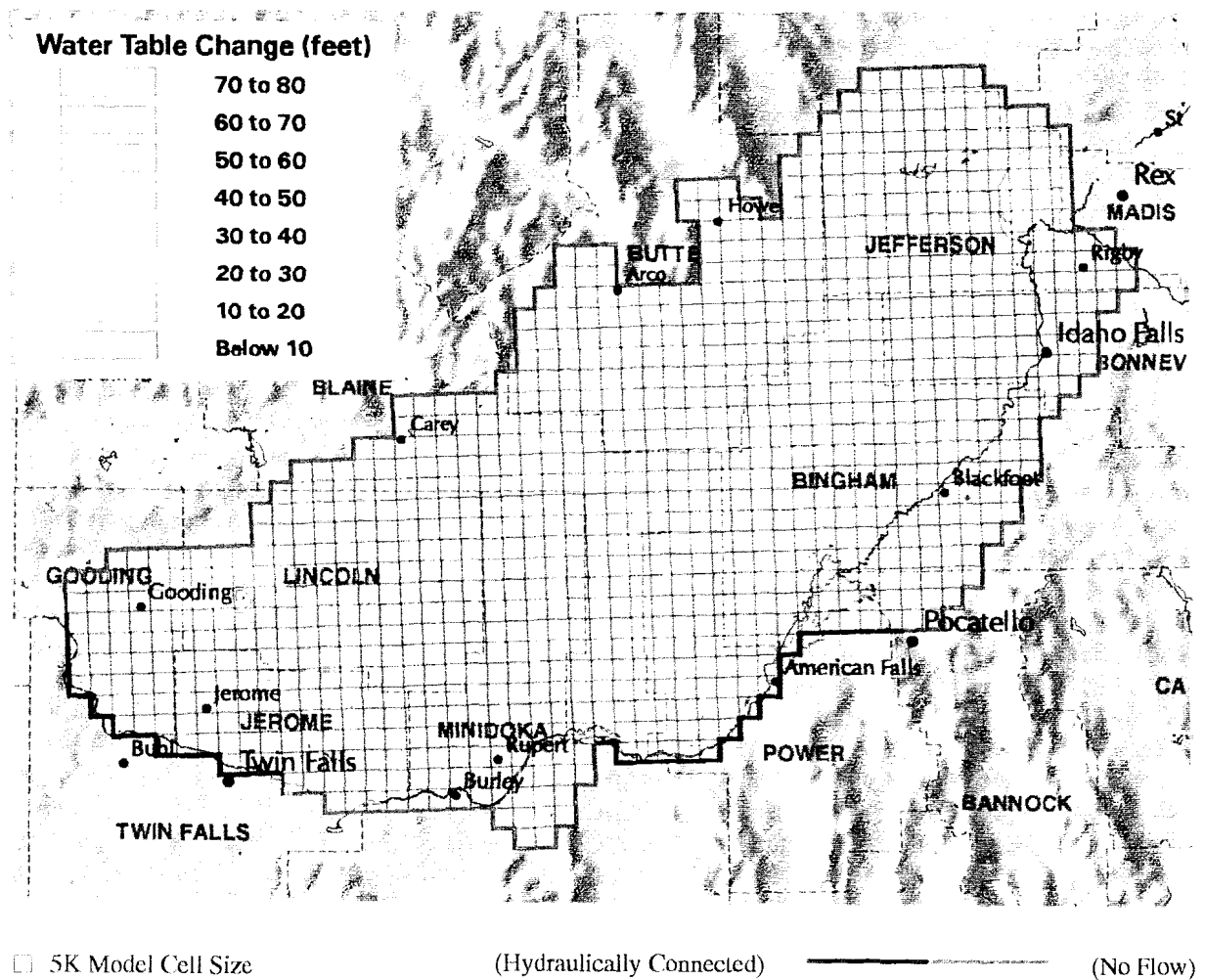# Figure 34. Change in Water Table Elevation Aafter 25 years for Managed Recharge Study Scenario A, Option 1

Table 16. Summary of Effects on ESPA for Managed Recharge Studies

Study	Difference in Computed Discharge from Base Study Shelley to Neeley (cfs)	Difference in Computed Discharge from Base Study Kimberly to King Hill (cfs)	Difference in gain to Henrys Fork from Base Study due to Change in HFA Leakage (cfs)	Difference in Computed Discharge from Base Study Shelley to Neeley (cfs)	Difference in Computed Discharge from Base Study Kimberly to King Hill (cfs)	Difference in gain to Henrys Fork from Base Study due to Change in HFA Leakage (cfs)
	After 25th Year of Simulation			After 100th Year of Simulation		
Scenario A, Option 1	155	146	122	172	167	126
Scenario A, Option 2	145	144	138	162	162	142
Scenario B, Option 1	20	18	13	22	21	14
Scenario B, Option 2	22	12	18	24	14	19